Conservation Economics
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Module 2
What is Conservation?
Lecture 1
Conservation in the Anthropocene

Namaste! Today we begin our new module: What is conservation? This module will have 3 lectures, Conservation in the Anthropocene, human population growth and food requirements, and unsustainable development. Let us begin with conservation in the anthropocene.

We have seen before what conservation is. Conservation comes from the two Latin word roots con which means together and servare which means to keep. So, literally conservation means to keep something together. What is this something? Conservation in the context of wildlife and in the context of natural resources means the preservation, protection and restoration of the natural environment and wildlife.

So, we are trying to do preservation, protection and restoration. There are three components of conservation: preservation, protection and restoration and we do the conservation of natural environment or natural resources and wildlife. Now, when we say conservation in the anthropocene, what is anthropocene?

Anthropocene is a proposed epoch. What is an epoch? An epoch is a time period in the history of Earth.

So, conservation is a proposed epoch which dates from the commencement of significant human impact. It begins from the beginning of significant human impact on Earth's geology and ecosystems including, but not limited to anthropogenic climate change.

So, it is a time period and this time period begins from the beginning of significant human impact on earths geology and on the Earth's ecosystems and it includes, but it is not limited to anthropogenic - which means manmade - manmade climate change. So, it includes manmade climate change it includes global warming, but it also includes a number of other things.

Now, what are those other things the first such impact is over consumption. Consumption by itself is not bad, but over consumption is striking. What is over consumption? Most of the natural

ecosystems and most of the natural systems have a rate of growth. So, if you consider a forest the trees in the forest are growing; you also have the next generation that is coming from the seeds. Similarly if you consider the oceans or any other water body you will have fishes and these fishes also have a natural rate of population growth.

Now, if humans remove this population at a rate, which is less than the rate of population growth, in that case the population of these trees or these fishes will either remain constant or they will go on increasing with time. But over consumption states that if you remove these organisms at a rate that is greater than the rate of the population growth - in that case the population will start to decline and that is known as over consumption.

So, one human impact on the environment is over consumption and these days we are over consuming literally everything. We are over consuming the fishes because of which the stocks of fishes in most of our oceans are going down. We are over consuming forests because of which we have seen massive deforestation. We are over consuming water resources because of which a number of water bodies are diminishing. We are over consuming the soil resources because of which there is a heavy amount of soil erosion and quite a lot of land is turning barren. We are over consuming most of the resources. So, over consumption is one major human impact on the environment.

Another one is habitat destruction. Habitat as we have seen is the natural home or the abode of an organism. If we damage that habitat - if we destroy that habitat - and why will we destroy any habitat - because of over consumption.

So, there is an animal that lives in the forest - let us consider elephants. Elephants live in the forest. Humans want to have access to wood and if humans take off most of the wood and if they convert these forests into a barren land, in that case the habitat of the elephant will be destroyed. So, habitat destruction is also a major human impact on the environment.

Another one is desertification. In desertification we are over consuming the water resources at such a rate that we are turning lands into deserts. A major factor in desertification is also overgrazing. Through overgrazing the cover of vegetation from the land is removed and when once this cover is removed the Sun's rays are able to heat up the land very quickly and dry up the land. So, excess removal of water as well as over grazing are leading to desertification.

Also we have ocean acidification. Ocean acidification means that we are converting the pH of oceans towards acidity which means we are reducing the pH of the ocean bodies. How are we doing that? A major factor is the release of carbon dioxide. When we are burning fossil fuels, when we are cutting down trees we are doing two things. One is that we are releasing carbon that was stored in the fossil fuels for a very long period of time - out into the atmosphere. When we are burning coal, when we are burning petrol, diesel, natural gas - we are releasing the carbon

that was stored inside the Earth into the Earth's atmosphere. And at the same time the second thing that we are doing is that we are removing those things that were removing carbon dioxide from the atmosphere. Plants remove a major chunk of carbon dioxide through the process of photosynthesis, but then out of our greed for land we are also destroying the forests.

So, on the one hand we are increasing the amount of carbon dioxide that is being released into the air and on the other hand we are also reducing the sinks of carbon dioxide. What happens when both of these things happen together? The level of carbon dioxide in the air starts to grow and when you have too much of carbon dioxide in the air it has to go somewhere. And carbon dioxide can dissolve in water. So, some part of this carbon dioxide also dissolves in the ocean waters. And when carbon dioxide meets with water it forms carbonic acid. And when you have an acid that is growing in concentration in the oceans the pH level of the ocean drops and this is known as ocean acidification.

And this is a very major impact on a number of ecosystems because quite a number of organisms that live in the oceans have calcareous shells made of calcium and calcium compounds say calcium carbonate. If you make the oceans into an acidic body what happens is that this calcium carbonate - it reacts with the acid and it dissolves - it converts into a bicarbonate and it dissolves in water. And so quite a lot of ocean reefs are getting affected. At the same time when the acidity of water - when the pH of water turns acidic this water is now no more capable of supporting a large number or a large variety of organisms - because every organism has a level of tolerance for a number of things. Not all organisms can survive in acidic waters.

So, when you turn the water acidic those organisms that are not able to tolerate acid waters - they will die off. So, ocean acidification is also a major human impact on the environment.

Next we have ozone depletion and a major cause of ozone depletion is the use of chemicals that are known as chlorofluorocarbons. These chlorofluorocarbons have been used for quite some time as refrigerants and also as propellants. Even in the case of a number of shaving foams we have been using chlorofluorocarbons as the agent that propels the foam outside from the can. Now these chlorofluorocarbons - they react with the ozone that is there in the stratosphere - and they deplete the ozone layer. Now once that happens - ozone is something that protects all life on Earth from the UV rays of the Sun - from the ultraviolet rays of the Sun. So, if the ozone layer thins or when it collapses, what happens is that more and more of UV rays from the Sun are able to reach to the Earth. And these UV rays can have negative impacts on a number of organisms. For instance they can lead to skin burns. They can even lead to some forms of cancers. They can increase the amount of or the rate of formation of cataracts in the eyes of different organisms. So, ozone depletion is another big human impact that we are seeing in anthropocene.

Now remember that most of these things did not occur before the impacts of humans was felt - because things like chlorofluorocarbons - they do not occur naturally on the Earth. This is a

completely manmade chemical and we have produced this chemical at such a vast scale that it has led to ozone depletion.

Next we have changes in the bio geochemical cycles such as nitrogen cycle. Bio geochemical cycles are the cycles through which nutrients move through the biological realm of the Earth which is the biosphere meaning all the plants and animals, it moves through the geological realm of the Earth which means that it is moving through the soil. So, this is a cycle through which the chemical nutrients are moving through the biological and the geological realms of the Earth. Common examples are things like carbon cycle or nitrogen cycle or phosphorus cycle or water cycling.

Now when we consider nitrogen cycle - nitrogen is a nutrient that is required for the growth of plants. It is also required for the growth of animals. Now, plants get nitrogen in the form of nitrites and nitrates from the soil. And how do these nitrites and nitrates form? Because we have nitrogen in the air - as much as 78 percent of the air is nitrogen - and when this nitrogen reacts with oxygen during lightning it converts into a nitrite or a nitrate and with rainfall it comes down to the Earth. Similarly, we have some organisms which are known as nitrogen fixing organisms. Common examples are Rhizobium, which is a bacterium, which lives in the ah root nodules of leguminous plants. Also other organisms like Nostoc and Anabaena also perform some amount of nitrogen fixation. So, these were two major routes - two major natural routes through which nitrogen from the air was converted into nitrites and nitrates and made available to the plants.

Now, what humans did was through the use of chemical cycles such as Haber process or Ostwald process, we are artificially converting the nitrogen in the air into nitrites and nitrates and using them as fertilisers - which is fine to some extent, but then an overuse of these fertilisers is also having a negative impact. Why? Because these chemical fertilisers affect the chemical structure of the soil; they affect the organisms that live in the soil. And when they are used in an excess amount quite a lot of these fertilisers also get washed down to areas where we do not want them. So, if these nitrogenous fertilisers - when they get washed down into a water body - then it essentially pollutes the water body because we did not make these nitrogenous fertilisers to be dumped into the water bodies.

Now, when these nitrogenous fertilisers are made available in the water bodies they have certain impacts. They will lead to a very rapid growth of plant material in the water bodies as well. And what will that lead to? If you have a water body - suppose you have a pond and there is a very heavy growth of algae - what will happen? The algae is taking up space in the water body. So, less and less of space is now left available for the other organisms such as fishes. A number of these water plants can also entangle the animals that are that normally live in the water bodies. And when we have a very rapid and profuse growth of these plants - after a while these plants will also die. And when they die - so much amount of organic carbon is there in the water body that needs to be degraded. And when the degradation of these plant bodies occurs it also takes up

the oxygen that was there in the water. And once that happens the level of oxygen in the water body goes down because of which a number of organisms are going to die. So this is a major impact. We call it as eutrophication of the water body which is the adding up of nutrients into the water body and this has very drastic and dramatic effects on the water body.

So, changes in the biogeochemical cycle such as nitrogen cycle through the use of mostly fertilisers is also a major human impact that was not present before the anthropocene - because earlier we did not have these chemical processes - Haber process or Ostwald process. And so the nitrogen that was brought to the Earth was brought in a very small quantity as compared to what we are putting into our soil and into our water bodies in the anthropogenic age.

Loss of biodiversity and extinctions because of a number of these factors and also because of the rampant poaching that humans do. There is a big loss of biodiversity: we are seeing a large wave of extinctions of organisms. Changes in the distribution of organisms, changes in biodiversity - why do we see changes in the distribution of organisms? Because of the changes that we are making to the surface of Earth. So, for instance if there is an organism that requires a water body and if humans come and they over consume the water that is there with the water body - this water body will dry off. Once that happens the organisms that lived in that particular place will either have to move to some other place if they are able to. Suppose they are flying animals or they are animals that can do locomotion on the ground - they will shift to some other places. But a number of other organisms will just perish. And so there will be a change in the localisation of biodiversity because in this area earlier we had say hundred species and now we do not have those species - probably we have some new species that have come up into this area. These are changes in the distribution of organisms - changes in biodiversity.

Then we have climate change. And a major causal factor of climate change is the release of greenhouse gases especially carbon dioxide. Now carbon dioxide - when it is there in the atmosphere - it acts as a greenhouse gas which means that it traps the heat of the Sun in the atmosphere. So, what it does is that it permits the short wavelength portion of the electromagnetic radiation - especially the infrared rays to come inside, but then when they are released back as long wave radiations - it traps them and slowly and steadily the temperature of the Earth increases. Now, once the temperature increases - it also has a number of other impacts because our winds or water currents are all related to the differences in temperatures that are there in different regions of the Earth.

If you increase these temperatures - if you take it with the natural distribution of temperature on the Earth - what happens is that the wind patterns change, the climatic patterns change. So, we might see things such as excessive drought or excessive rainfall that leads to floods or very high increase in temperatures which may lead to things like heat stroke or very drastic climate change events such as cyclones. All of these increase in their intensity - the increase in their duration and the increase in their probabilities. This is climate change. We also have non manmade climate

change, but the level of climate change that is being brought about by human activities these days is so high that it has overwhelmed the natural levels of climate change. So, this is another major human impact on the environment.

Other impacts include soil erosion changes in geomorphology, deposits derived from concrete lime mortar or other calcareous materials outside the cave environment. So, changes in soil erosion, changes in geomorphology are also major human impacts on the environment.

Then we have changes in stratigraphy due to increased sediment load and deposition because of deforestation, construction activities and so on. Now, changes in stratigraphy - it means that there is change in the levels or the layers of soil that are naturally present. And why do we see these changes? We are observing these changes because of a huge amount of sediments that are being brought - through mostly the river systems and the water systems - into the lakes. So, earlier suppose we had every year - we had 1 millimetre layer of soil that was coming naturally, but then because of deforestation and because of agricultural activities and other activities now we are seeing not 1 millimetre, but say 10 millimetres of soil that are coming. This is leading to changes in stratigraphy.

Then changes in the elements in the atmosphere: C 12 or carbon 12, that is released from fossil fuels; radionuclides that are released from nuclear fallout and atomic reactors. We are not just seeing changes in the amounts of elements that are there in the atmosphere, we are also seeing a change in the radioactive levels of different elements that are there on the planet Earth.

Now, changes in C-12 concentration - why does that happen? Because the fossil fuels that we are using were made from carbon that has been stored for many years - many thousands of years or many millions of years. Now, in that long period most of the radioactive carbon which is carbon 14 has disintegrated and has converted into other nuclides. So, the amount of radioactivity that you will have in the carbon that was stored for a very long period of time will be much lesser than the amount of radioactivity that we see in the current carbon - because carbon fourteen is regularly being produced in the atmosphere. Now, if we release a large amount of carbon twelve - because we are burning the fossil fuels - that is changing the carbon twelve carbon fourteen ratio that was there in the atmosphere. Now this will not have a very drastic impact on most of the organisms, but yes this is a change that is brought about by human beings on their atmosphere. So, this is another indication of the beginning of anthropocene. When we start seeing changes in the radioactive ratios in different gases or in different elements - that would give us an indication of when anthropocene begins. And similarly we are seeing radionuclides that are released from nuclear fallout and atomic reactors and a number of these radionuclides just did not exist before humans brought them on Earth.

Then we are seeing changes in soil - because of water logging, desertification, buildup of pesticides and other chemicals, and a lot of this has to do with agriculture. Because of

agriculture, when we are storing water in certain areas, when we are constructing canals - it is leading to water logging in certain areas. Also when we are doing excessive irrigation for water thirsty crops - and if the soil is unable to tolerate that much amount of water, then it might lead to water logging.

Then we are seeing desertification in those areas where we are excessively taking out water and we are also letting animals perform overgrazing. That is leading to the soil turning into desert soil. Then there is buildup of pesticides and other chemicals that are being sprayed especially for agriculture, but also because of those chemicals that are being released due to industrial activities. That is leading to major changes in the soil.

Introductions and invasive species: what humans have done is that they have been a medium of bringing different species from one part of the Earth to another part of the Earth. Now, some of these introductions are done voluntarily. So, for instance a species such as lantana was brought from Africa into India because there were some humans who thought that this is a beautiful looking plant and we should have them in the hedges, we should have them in the gardens here. And so this plant - Lantana camara, it was brought from Africa into India and when it came to India it became an invasive species - because the other species in Africa were able to tolerate this species - they were able to keep this species in check, but our species were did not evolve with this species - Lantana camara; they did not know how to deal with this species. So, what happened was that in a very short period of time this lantana entered into our forest and slowly and steadily it replaced the native species in a number of areas and it became the predominant species. Now this is an introduction of a species that was done through volition because humans wanted to bring this species from one place to another place. But then we also have a number of involuntary species introductions especially because when humans move from one place to another place a number of organisms are also able to hitchhike on the aircrafts, on the ships and they are able to come from one place to another place. Similarly, major introductions also happen in the form of food articles. So, for instance if there is a person who is going from say Africa to Australia and is taking certain food items - say certain fruits with him or her into Australia. So, what is happening is that the seeds of these fruits are also coming this with this person into Australia and when these seeds reach into this place then it is possible that this species of plant gets introduced into Australia. Now, nobody wanted to introduce this species into Australia, but then involuntarily because humans are moving from one place to another place and they are taking things with them - then it is leading to the introduction of species. Another good example is the movement of a number of organisms through ballast water. Now this is something that we will see later on in a lecture, but in short what happens is when you have a ship that is moving from one place to another place, for maintaining the stability of the ship, whenever the luggage in the ship is removed - whenever the cargo is removed, some water from the ocean or the water body where the ship is residing is pumped inside the ship so that it maintains its level - it does not rise and sink with the load. It has to be maintained at a constant level. So, whenever you are putting the load inside this water will be pumped out - the same

amount of weight as that of the cargo that you are putting in - and when the cargo is removed water is pumped inside.

Now what happens is that when you are pumping this water inside the organisms that are living in this water also are able to enter into this ship in the form of the ballast water and when the ship moves to another area and when this water is pumped out the organisms that were there in this ballast water are now released to the new environment. Now, it is possible that if these ships were not moving or if these ships were not using the ballast water it is quite possible that these organisms would have never moved from one place to another place. But then because of these ships that are using the ballast water, we are now seeing introductions of a number of organisms across continents and a number of these organisms are also invasive species which means that they grow at a very fast pace. And they also are able to overwhelm the natural species that are present in the new location - and in a short while we will observe that they have overwhelmed the local populations - they have led to a rapid decline or a collapse of the indigenous species - and they have established themselves. So, this is also a major impact of humans on the environment.

Then we have pollution including light pollution that we are seeing because of the humans. We are observing coral bleaching. Now coral bleaching - it means that because of changes in the water of the oceans especially because of acidification and because of pollution a number of corals die off - and when they die off the colour of the coral changes - it becomes white in colour. It becomes bleached. Bleaching is an indication of the death of corals. Now corals are those species or coral reefs are those formations that support a number of other species - because fishes can lay their eggs inside these corals, a number of other organisms can find their safety inside these corals. So, corals are very important formations for biodiversity and when coral bleaching occurs we also observe a rapid and a massive decline in biodiversity in those areas. Coral bleaching is also another human impact on the environment.

One more impact is wars. And wars are not just tragic from the human point of view, but they are also tragic from the environmental point of view because they release massive amounts of noxious substances into the environment which leads to a massive decline in biodiversity. So, these are some human impacts on the environment that we are observing in this epoch called anthropocene.

Traditionally we take the beginning of anthropocene as the day on which we had the Trinity explosion in 1945. So, this is the beginning of the nuclear age and this date is taken as the beginning of anthropocene.

Now, over time humans have become more and more conscious of the the impacts that they are having. And so, these days we also see - especially in the 1960s we started talking about things such as The Population Bomb. We started to realise that our populations are growing at such fast

paces that it is now becoming impossible for nature to tolerate us. And so we started talking about the population bomb - that if we do not control our populations in a very short period of time we will over consume so much of resources that we will have nothing left. We started talking about - are there certain limits to growth? We all want to have growth - we all want to have development, but is there a limit to growth? Because if we have a large population and because of development we are providing them with so much amount of resources that - if we have a large population with a large amount of affluence because of development it will lead to an overconsumption of a number of resources. So, is there a limit to the growth? Is there a limit to the development? We started talking about these things.

And we started talking about how do we quantify the impacts that humans are having on the environment. And we came up with this formula:

I is equal to P into A into T.

I here is the impact of human activity on the environment. P is the population in the area and this area could be as large as the whole world.

So, what this formula is saying is that if the population increases the impact of humans also increases. So, I is directly proportional to P. I is also proportional to the affluence. Now affluence is the average consumption of each person in the population. So, affluence is telling us how much amount of resources are being consumed by one person. Affluence is generally measured through values of GDP per capita.

And what affluence is telling us - is that if you have more amount of resources - you are over consuming the resources - the more affluent you are the more amount of resources you are using. And so the amount of impact that you will have by using a large amount of resources will also be large.

So, I is also proportional to A. And I is also proportional to the technological advancement or a measure of how resource intensive the production of affluence is. So, I is equal to P into a into T. If you increase the population you will have more impact, if every person in the population starts to use more amount of resources you will have more impact, and with a more - better technology you will be able to provide these resources to the people. Or this technology may also be at times used to overcome the impact.

But in most of the cases what we have seen so far is that with more and more technology we are also increasing the impact - because of the need for more and more materials and because of an enhanced efficiency of the processing of these resources. So, I is equal to P into A into T. Now, let us now observe how P and A and T have been changing through time.

If you look at the world population we find that the world population for a very long period was nearly constant. Then it started to increase and then roughly around the time of Industrial Revolution, we see that it has started to rise very quickly. So, this is now the exponential growth of population and now it is going at a very fast rate. And in the next few years it will reach somewhere near 10 billion - currently we are around 7 billion.

So, the world population has been increasing very fast. So, the P component of I is equal to P into A into T has been increasing and the rate of increase has also been increasing. So, it is now an exponential increase in population. If you look at the density of populations there are a number of areas, where the human population density is very large. In those areas where we have a large human population we have seen that the impact of humans will be large and so these are the areas where also the impacts of humans will be large. Now if you consider our country - our country is one of the more densely populated areas of the world and because we have a large human density - because we have a large human population we need a lot more resources to feed these people. So, essentially the amount of agricultural expansion has been increasing with time. Now with the need for more agriculture we need more land because of which we are cutting up more and more of the forest. We want to provide affluence to all these people because of which we require more and more resources because of which again we are cutting down a number of forests and we are using those areas for things like mining.

So, any area that will have more population will also have more impact and what we are observing here is that not only the population has been increasing with time and the rate has been increasing with time, but also there are certain locations on Earth where the population density is very high and that has an impact on the total human impact on the environment. The population densities have also been growing over time in a number of areas.

Now, let us have a look at affluence. Affluence can be measured by how much amount of resources are made available to each and every person to consume. If a society is able to produce more resources those resources are available for people to consume. So, we can have an indication of the amount of affluence through a measurement of the amount of industrial productivity.

We can observe here that the productivity of a number of items has been increasing and we can see that around 1600 or 1650 AD we see a rapid change. Before that this curve was roughly horizontal and after this it has been rising exponentially. So, this can be an indication of where we started to have more impact on the environment.

Affluence can also be measured in terms of money that people have and if you look at world GDP over the last 2 millennia we see that here again we are seeing an exponential growth. Roughly after around 15 - 16 hundred AD we start seeing an exponential growth. So the affluence has also been increasing with time.

When we say I is equal to P into A into T the P component has been increasing the A component has also been increasing.

Now, if we wanted to know how much is the impact of people in different areas we can look at GDP per capita in different countries of the world. And here we will observe that the areas such as the United States or the UAE - they have - or most of the western Europe or Canada - they have a very high GDP per capita which means that the affluence in these areas is large.

And the GDP per capita has also been increasing with time, and this rate of increase has also been increasing with time. What that means is that not only is the affluence increasing, but the rate of increase has also been increasing - which means that in a very short period of time we will reach very unsustainable levels of affluence. If nothing is done to stop the impact then probably it will lead to drastic consequences.

Now, let us observe what is happening in terms of GDP per capita if we consider two different time periods. So, in this curve the GDP per capita in 1960 is represented on the x axis and the GDP per capita in 2014 is represented on the y axis. Suppose the rate of growth was the same everywhere. So, that would have led to countries that would have been on this line - this line at 45 degrees is showing that if you had say 500 GDP per capita in 1960, you also have 500 GDP per capita in 2014 - which means that there is no change in the GDP per capita - there is no change in the affluence.

Now, what we are observing with this curve or with this chart is that most of the countries are on the left side of this curve, which means that most of the countries have - or are observing increase in the GDP per capita. There are only a few countries in the world which are actually seeing a decrease in the GDP per capita, but in most of the countries the GDP per capita has been increasing by which you can say that the affluence level in most of the world has been increasing with time.

Now let us have a look at the T component - the amount of technology that is available to the society. Now we can use certain indicators to assess what is the rate of technological progress. We can look at Moore's law - Moore's law is an indication of the number of transistors that are there in a microprocessor and it says that the number of transistors in a dense integrated circuit doubles approximately every 2 years. So, what Moore's law is saying is that if you look at an integrated circuit the number of transistors will double every 2 years. Now this was an observation that we had earlier in the 1960s. What is the position at present?

Well we are observing that actually the number of transistors has been roughly doubling every 2 years and we are observing an exponential increase, which is an indication that we are seeing a technological progress that is also increasing exponentially, which means that the T component

of the equation I is equal to P into A into T has also been increasing and the rate of increase has also been increased.

Other indicators include things such as the the super computing power that we have. So, if we make a plot of the super computing power in terms of FLOPS, we will find that here again we see a roughly exponential increase. Increases in the microprocessor clock speed - this is another indication of technology. Here also we are observing an exponential increase in the microprocessor clock speed with time. So, T has been increasing and this rate of increase has also been increasing with time.

The sequencing cost per DNA - the number of human genome base pairs that are sequenced per US dollar - that is also increasing - which means that for every dollar we can now sequence more and more amount of the genome which is a good indication of the technological progress.

So, what we are observing here is that in the equation I is equal to P into A into T, P is increasing, A is increasing, and T is increasing - and all three of these are increasing exponentially - which means that the impact has also been increasing at a very fast pace.

Now, if you look at the impact of humans, we can divide the human history into 3 different stages. In the early society - in the aboriginal society we had small P, small A, and small T - small population, less amount of affluence, less technology. Because there was a small population, so, there were less number of mouths to feed. There was a less requirement of resources because the affluence was low. People just did not feel a need to have more resources - they just did not know about having resources such as air conditioners or computers. The affluence was very less and the technology was also missing. So, in those days even if there were some people who wanted to have more and more resources, the technology was not present to enable them to extract these resources from the environment. So, the P was less, A was less, and T was less and so, there was a little impact on resources - and the resources were in plenty.

There was a little need - there was hardly any need to conserve the resources - though in certain societies certain fruit or food or fodder trees may may have been conserved as religious trees. So, what was the thinking of humans in those times? The thinking was that nature - or mother nature is providing us everything in plenty. And there is nothing that we need to do to conserve because our requirements are so less - and the amount of resources that there is available - it is so large in comparison that even if we do all the exploitation that we can, that is not going to have any impact.

So, in the aboriginal societies we see that there was hardly any talk of conservation although a few trees such as the fruit trees or the fodder trees - they were revered as religious trees and so they were conserved. We had a feeling - a very small feeling of conservation that was mostly religious - that had little to to do with the amount of impacts that we have on the ecosystem. That

is the first stage of development of the society.

Then we moved to stage number 2. In stage 2 we started seeing modernisation of the society. With modernisation of society - it actually began with technological improvements - if you have better technology you can have more resources. If you have more resources you can increase the affluence of people and if you have more and more people who are more and more affluent, they are protected from diseases, they are having a large lifespan or their lifespans are increasing and at the same time they do not have to work so hard because technology is there to help them out. In such a situation the population will also start to rise. So, with the beginning of modernisation we start seeing a growth in population, a growth in affluence, and a growth in technology - and so there is a growing impact on the resources due to unabated exploitation and resources are now getting scarce with time.

So, with the development of modernisation we actually started feeling a crunch - that yes our population is growing fast, it is growing more and more affluent and we are getting more and more technology, but then now there is a dearth of resources. For instance we had means to convert iron ore into iron, but then now we were seeing that the iron ore that was available in the surroundings that has now become exploited. And so now we require more sources of iron ore - because we have technology to convert it into iron and we have a population that has been increasing and this population wants this iron. Similarly with affluence there was a need for a number of new items. People wanted to build fancier homes. So, they wanted more amount of wood, but then the local forests are now empty because we have a better technology to cut these forests and we cut these forests. And so now, these forests are gone, but then there is an increase in population and with increasing affluence they also want more and more of wood. What do we do?

So, modernisation was also a time of expansion. There was an increase in need to conserve the resources, but then this need was not a very hard pressed need - because for the time being the need for resources could easily be met through expansion of the empire. So, we start seeing the expansion of empires such as the Roman Empire or the British Empire and in a number of these situations what these empires did was to make other areas their colonies - which meant that the people in these empires had now access to resources in other areas as well. So, there was little need to conserve the resources and there was a possibility to get these resources from other areas and this was done through an expansion in the empires and through the development of colonies.

But then we moved into the third stage - which is the modern society. Now, in the modern society the population is large because it has been increasing with time, the affluence is large, the technology is large, but then all the areas that could have been brought into the hold of the empire - they have already been brought into the hold of the empire. Now we do not have any more land to bring to the empire. What do we do now?

So, there is a large impact of resources - because of unabated exploitation the resources are extremely scarce, but then there is no more land to bring into the fold - there is no more land to exploit and so, now the resource conservation has become extremely imminent - because we do not have any other option - we do not have the option of bringing in other lands to get these resources.

And so the only option that is left is to conserve what we already have. And so scientific management of resources gets born as a discipline to meet the needs of the society. The modern society is now putting a lot of emphasis on conservation and on sustainable use of resources.

But then we to make use of these resources in a sustainable manner we not only require this feeling or this devotion to conservation, but we also require means to perform these operations. So, we need not just a willingness, but also the technology and also the economic inputs that will make this possible. Most of the world from the mid nineteenth century is now in this stage. So, conservation has become a very important part of life these days.

Now, not everything is going that bad because we can also see a number of silver linings. There is a more and more - greater - emphasis on recycling of resources, recycling of things like plastics. If we see the percentage of plastic that was recycled in the nineteen eighties - there was hardly any. But today we can see that almost twenty percent of the plastics is getting recycled. Now of course, the amount of production has also gone up. So, if we look at the amount of waste that we were generating in the 1980s that was nothing compared to the amount of waste that we are generating now. But at least now there is an emphasis to recycle things - there is an emphasis that we should not dump these plastics out into the atmosphere - or out into the environment - out into the water bodies. We should not just go and burn them off to release noxious fumes into the environment. There is a much greater emphasis on recycling things and on disposing these waste items in a more prudent manner.

Another silver lining is that the rate of population growth has already peaked. We are now in a stage where the rate of population growth is decreasing with time. Now even though our populations have been increasing, but the rate of increase has now gone down and the rate of increase is now going down very quickly. In a short period of time we might even move to a stage of a stable population. If we look at the population growth we can see that this is an S-shaped curve. And in this S-shaped curve we are currently in the middle. We can now project that the world population will stabilise at around 10 or 11 billion people.

The rate of population growth is determined by the slope of this curve. The slope of this curve was very high in this region and it goes on decreasing when we reach here. So, the slope is less and we are right now in the middle. We have already crossed the peak population growth rate and the growth rate of population is now going down - which is a good news.

Another thing is that we are observing reducing fertility rates in a large number of countries. The fertility rate - or the number of children that a woman would have on an average - that is also going down. Your parents or your grandparents had many more siblings and we are also observing changes in the population pyramid. So, in the 1950s we had a population pyramid that had a much greater base as compared to the top, but now we are shifting to a population pyramid that does not taper. This is also an indication that the rate of population growth has been decreasing - and it will further continue to decrease when these children reach their adulthood. We are also observing demographic transitions in most of the areas of the Earth.

Now, what is a demographic transition? A demographic transition tells the story of a society in terms of different stages. In the first stage we have a society in which we have a high birth rate and a high death rate. Now because you have a high birth rate every woman or most of the women on an average have a large number of babies and most of these babies also die off very soon - because there is a high death rate. And this death not just happens in the time of childhood - it also continues into the adulthood.

Now, why do we have a society like this? Because we do not have advancements in medical care. So, there is no way to fight diseases and a number of people die out of diseases. Now because the death rates are high, if the society has to continue, it should maintain a high birth rate as well. So, this is the first stage in which you have a high birth rate and a high death rate.

Now, with advancement of technology people start working on ways to reduce the death rate - and the ways to reduce these death rates are medical advancements. So, we come up with ways of treating diseases - we come up with antibiotics, we come up with antiseptics and so on. And slowly and steadily we are able to bring the death rates down. But then we have not done anything for reducing the birth rate.

So in this state we have a society that has a decreasing death rate, but still continues to maintain a high birth rate. So, more number of babies are born and less number of people are dying. In that stage we will start seeing an increase in the population. So, the total population will start to increase. In the first stage the high death rate and high birth rate were able to counter each other and the total population growth was less - which is what we saw for most of the presence of humans in the human history. But then starting from say around 1500 AD we start seeing a large increase in population - because we have now now started to bring the death rates down now. With this exponentially increasing population people then start feeling that yes - this population is growing so fast that in a short period of time it will overwhelm the resources that we have - and so, now the society starts to look at ways to reduce the birth rates as well. And how does society reduce the birth rate? Well it comes up with things like contraceptives, it comes up with education - and with more and more people going out to work and being being productively employed, there is a less and less incentive for people to have more and more number of babies. Why? Because in earlier times every couple used to think that ok, if I have more number of

babies, I have more hands that are going to help me out in the fields - that are going to help me out in my profession. But now with the increase in technology we have things like tractors available for us. So, even if a farmer has a single child he or she might be able to perform all the duties of the field without the need for any more hands - because we now have access to machines. Similarly in the earlier times people used to think that because of the high death rate it is possible that a number of my children are going to die off, but now everybody knows that yes we have such good medical facilities that most of my babies are going to survive and so, people make this conscious decision that we should have less number of babies. And so, in this third stage the birth rate also starts to fall. Now in this case the death rate is still falling - because we are still working on medical advancements. But now the birth rate has also started to fall and so, the population growth will now turn towards a plateau. And in the fourth stage we have a low birth rate and a low death rate. And so, the population now stabilises. There is no further increase or decrease in the population and the population stabilises.

So, this is a demographic transition that we have observed in a number of societies - and the silver lining is that with the increase in technological progress we are observing this demographic transition in more and more areas - we are observing that we have brought down the death rates and we are also bringing down the birth rates.

So, anthropocene is an epoch in which humans have put a very huge amount of impact on the ecosystems - a very huge amount of impact on the geology. But then the silver lining is that we are now shifting towards reducing these impacts.

That is all for today. Thank you for your attention. Jai Hind!